

Modeling Post-Accident Vehicle Egress

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Abstract

This paper describes the application of the Jack human figure model to the analysis of vehicle egress by military personnel following an accident. In post-accident situations, the vehicle attitude may preclude egress by the normal methods that have been addressed in most previous research. For this analysis, the Human Motion Simulation Framework reference implementation was used to aid the simulation. With the current level of functionality, only basic clearance issues could be investigated; improvements to the Humosim Framework and Jack software are needed to enable rapid and accurate generation of motion simulations for these non-standard situations.

Keywords: Digital Human Model, Ingress, Egress.

1. Introduction

Vehicle ingress and egress are among the tasks most commonly studied using digital human figure models, such as Jack (Baker 2012). However, the unique requirements of military applications have challenged the capability of current software. Soldiers are often wearing and carrying a considerable amount of gear that is not represented in the motion-capture datasets on which most simulation tools are based. Moreover, the analyses of interest for military situations may involve rolled-over vehicles for which detailed movement data are not available.

In the current design process for military vehicles, ingress and egress are evaluated by acquiring vehicles (when available) or by building expensive mockups and running timed test trials. These evaluations are expensive and time-consuming, and are often performed late in the design process when it is too difficult to alter the design if weaknesses are discovered. Yet, due to the limitations of current software tools, digital human models (DHMs) are not yet widely used.

This paper presents a case study of the application of the Jack DHM to analysis of egress from a vehicle following a rollover event. The application of Jack was aided by the use of the Human Motion

Simulation Framework reference implementation. The Framework is a suite of data-grounded algorithms and tools for efficient and accurate simulation of static postures and dynamic motions (Reed et al. 2006). The Humosim Framework has previously been applied to simulating driver ingress and egress for passenger cars and light trucks (Reed and Huang 2008). For the current study, two scenarios were simulated: egress through the windshield opening of a vehicle lying on its side, and extraction of an incapacitated driver through the passenger-side door of a vehicle lying on its side.

2. Materials and Methods

2.1. Human Models

For the windshield egress and assisted egress studies the manikins shown in Figures 1 and 2 were utilized. These Jack v7 manikins were created using scaling based on the ANSUR (Gordon et al. 1988) anthropometric database, choosing 50th- and 95th-percentile male statures as the target dimensions. All other dimensions are scaled to be appropriate for the corresponding statures of 1755 and 1875 mm. These manikins are termed the midsize-male and large-male manikins for purposes of this analysis.

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Geometry representing body-borne protective equipment and other gear was added to each figure. Full encumbrance is defined as: improved outer tactical vest (IOTV) with additional gear and hydration pack. (The helmet, which would normally be part of the protective gear, was excluded due to problems with the available CAD geometry.) The additional gear caused no change in the DHM shoulder width and the waist to grow by 100.3 cm for the midsize-male using the large vest. The large-male waist increased by 78.4 cm by using the extra large vest. The fully encumbered DHMs can be seen in Figures 1 and 2.

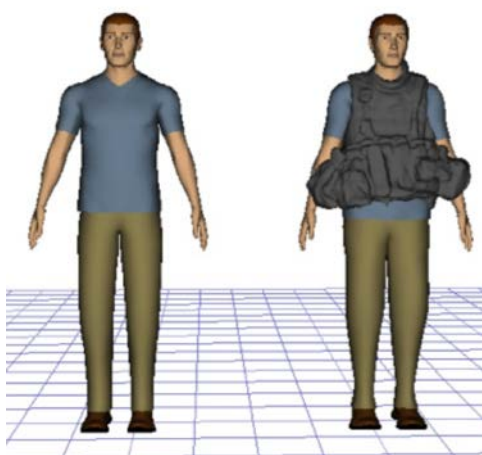


Figure 1. Midsize-male manikin unencumbered and encumbered.

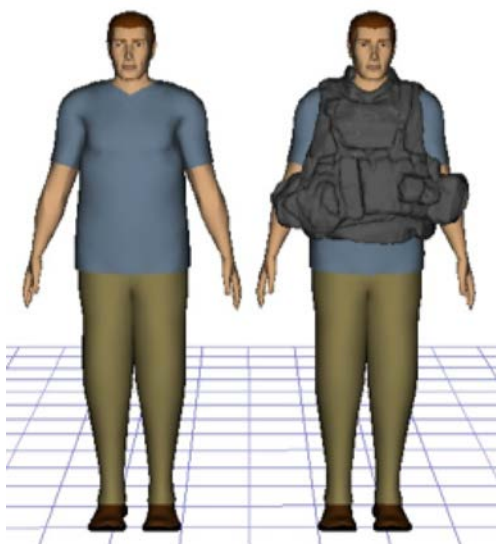


Figure 2. Large-male manikin unencumbered and encumbered.

2.2. Windshield Egress

CAD geometry of a representative vehicle was obtained and imported into the Jack environment. To create all simulation components for the windshield egress, the DHM was manipulated into crawling postures for egress through the military

vehicle windshield. The initial posture was a crouching posture on the driver door with the DHM facing the windshield. The following postures were the best case postures based on subject matter expertise. Each posture was saved into the Jack posture library for utilization during simulation development. All simulation components were input into the simulation environment utilizing the Framework.

2.3. Assisted Egress

The analysis of assisted egress for an incapacitated driver was performed statically to identify geometric constraints that could limit safe extraction in the field.

The research team assumed the pull point for egress was located on the back of the vest near the neck. The equipment used to remove the incapacitated driver is located at the base of the vehicle and was not simulated. The initial position in the driver seat is pictured in Figure 3.

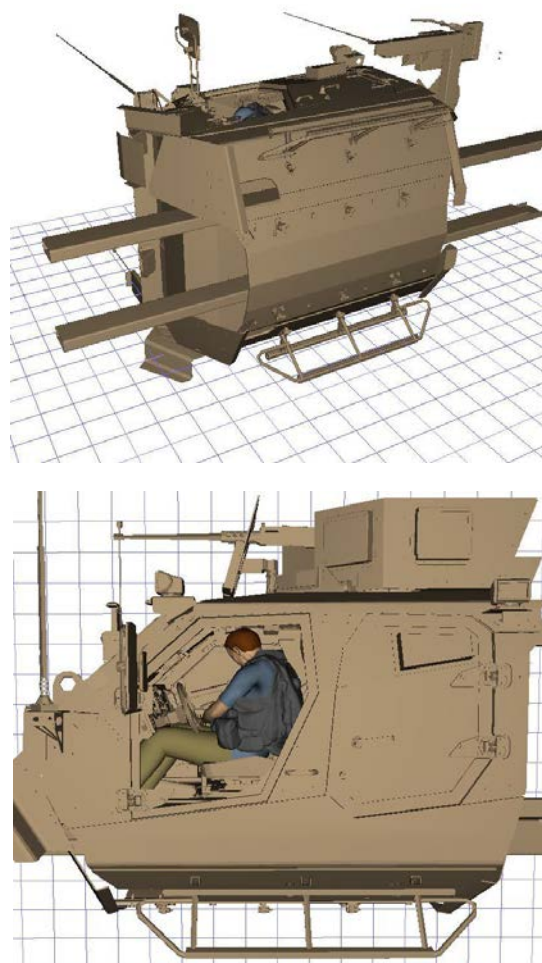


Figure 3. Large-male encumbered manikin in the initial position for assisted incapacitated egress.

3. Results

3.1. Windshield Egress

The simulation immediately demonstrated that an encumbered large male would not be able to egress through the opening the windshield provided. Figure 4 shows a red line representing the area of collision between the DHM and vehicle. Further investigation showed that the encumbered midsize male would not be able to egress either.

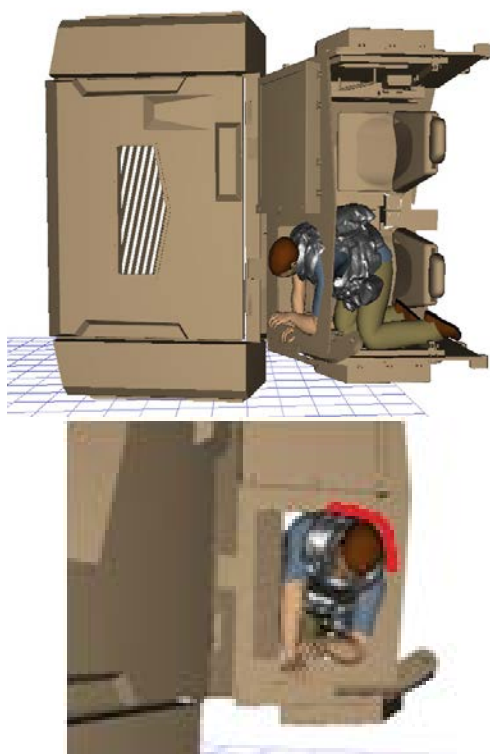


Figure 4. Windshield egress of encumbered large male DHM. Red lines indicate interference.

Measurement of an exemplar vehicle documented that the vehicles as-built have slightly larger window frames, so the simulation was repeated with adjusted geometry. However, the simulation demonstrated that even the enlarged window frame was insufficient to allow egress by encumbered occupants. To provide guidance for future vehicle designs, the amount of space required for egress by encumbered occupants similar in size to the manikins was computed.

3.2. Assisted Egress

A part of the analysis was to determine if a collapsible steering wheel would be useful or necessary to facilitate assisted egress. In Figure 5, the male manikin is in an intermediate egress position while the steering wheel is highlighted to show the interaction of the Soldier with the steering wheel. Additional postures during the egress simulation are shown in Figure 6.

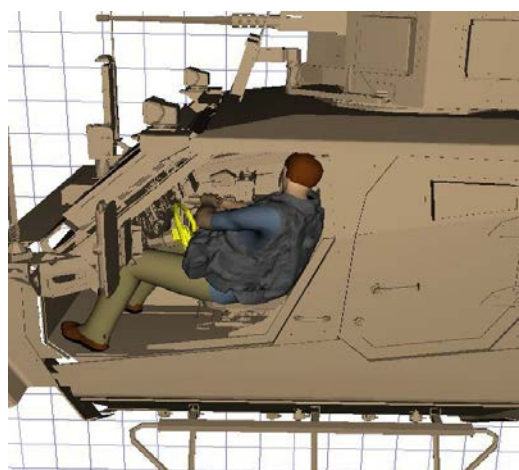


Figure 5. Large-male encumbered manikin in the intermediate position for assisted incapacitated egress.

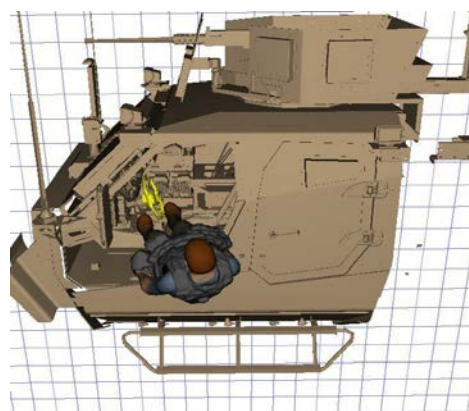


Figure 6. Large-male encumbered manikin in the final position for assisted incapacitated egress.

4. Discussion

These case studies demonstrated the value of the DHM simulations for identifying geometric clearance issues associated with egress by encumbered occupants. To our knowledge, this is

the first study to address encumbered egress from rolled vehicles.

Although the Humosim Framework provided a useful starting point for conducting the simulations, the lack of data on appropriate postures meant that the analyses were essentially conducted manually, with little benefit from the Framework algorithms. Even the combined capability of Jack and the Framework lacked important functionality for these simulations.

First, capability to simulate ad-hoc motions, such as crawling using affordances from vehicle structures not designed for egress, is needed. Second, data on human capability for attaining and sustaining the unusual postures and motions needed for these sorts of egress tasks is needed.

5. Conclusion

The Jack human modeling software, combined with the Humosim Framework reference implementation, was used to simulate egress by encumbered occupants from a vehicle following a quarter-turn rollover. The software was effective in documenting important clearance issues, but lacked the capability to automatically generate postures and motions. Further research is needed to develop the data foundation to simulation these types of activities and to provide simulation capability in software.

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